Adobe™ Photoshop™ on Sun®

Performance Brief

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Adobe Photoshop

Introduction

Adobe™ Photoshop™ is widely recognized as the single most popular volume application in imaging environments. In this role, Photoshop has contributed to the dominance of the Apple Macintosh® in the desktop publishing and prepress community. Over the last few years, these same prepress and publishing users have discovered the benefits of Sun® servers and workstations in delivering specialized computational, I/O, and image management services. Today, Sun systems represent the largest UNIX® installed base in the printing and publishing industry.[1]

The recent availability of low-cost, high-performance 24-bit UNIX desktop systems has motivated Adobe Systems to migrate Photoshop to Sun Microsystems® SPARCstations® — the highest volume UNIX platform in the industry. This document examines the performance of Photoshop on a variety of Sun and non-Sun platforms.

1. According to CI/Infocorp reports dated March 1994, Sun is ranked number one (31 percent share USA, 25 percent share worldwide), with Hewlett-Packard a distant second at 17 percent.

Overview of Adobe Photoshop

Adobe Photoshop is a powerful image processing application, with broad versatility that permits its use as a paint, prepress, digital photography, color correction, and image editing program. Photoshop's uses are as broad as its users — virtually anywhere electronic images are manipulated, Photoshop has a place.

Adobe Photoshop, despite its distinct capabilities, has also evolved considerably since its inception in the late 1980's. Initially establishing Photoshop and the Apple Macintosh as a standard in volume desktop-based publishing environments, Adobe has gracefully added both new features and support for new platforms.

Like other resource demanding applications, Photoshop requires considerable floating point and integer processing, graphics, I/O, and other system-level performance characteristics. Photoshop users are virtually unanimous in their demand for high performance which — not surprisingly — is where Sun's UNIX-based RISC workstations and high-speed networking shine.

Adobe Photoshop on Sun

Adobe Systems ported Photoshop 2.5 to Sun platforms in late 1993, as part of a directed effort to establish itself in the rapidly growing UNIX marketplace. Among the key considerations Adobe faced in their decision was the performance benefits of SPARC®-based systems over other architectures such as the Intel® x86, Motorola® 680x0, and PowerPC®. Equally, UNIX workstations were renowned for fast, high-resolution graphics, and standard, bitmapped window systems.

Additional considerations which led Adobe to porting Photoshop specifically to Sun workstations included Sun's broad acceptance in the workstation market, as evidenced by the large number of applications and leadership position in the UNIX marketplace. Equally, Sun has pioneered integrated imaging technology such as the SX and S24, which are particularly important to applications like Adobe's Photoshop. And lastly, Sun has led the industry in delivering desktop multiprocessing expansion capability.

When Sun first introduced the SPARCstation 10SX workstation in mid-1993, the stage was set for delivery of truly optimized Photoshop performance in a multitasking environment. Photoshop's innovative plug-in architecture

enabled application and tool vendors to extend Photoshop to use their optimized code for operations such as filters, compression, special effects, scanner control, and other capabilities. The SX architecture in particular included advanced imaging features which Photoshop was able to exploit.

By mid-1994, Sun Microsystems had introduced the SPARCstation 20SX and the SPARCstation 5 S24 workstations — both uniquely positioned to deliver the industry's fastest and most cost-effective Photoshop performance.

The benchmarking tests provided here represent a set of 14 key operations, performed on a variety of platforms including those from Sun, Silicon Graphics®, and Apple. The following sections provide details of their configurations and performance results, and a discussion of the individual Photoshop operations.

Benchmarking Photoshop

The most important consideration for many Photoshop users is simply execution speed. To help characterize this for users, a well-defined set of benchmarks were performed on Sun, Silicon Graphics, and Apple Macintosh systems. Due to the significant number of Photoshop operations, and the overwhelming mass of data associated with them, this brief includes a subset of 14 operations from the complete set of over fifty. These operations were chosen on the basis of two principle considerations: (1) their common usage in imaging and prepress, and (2) their broad dependence on system resources (integer and floating point computation, memory, and disk).

Each test was performed a minimum of three times to guarantee accuracy in representing actual performance. To ensure that the impact on memory and disk was considered, each set of tests was completed on two different file sizes: 4.84 Megabytes and 72 Megabytes. Further, in evaluating the capabilities of the multiprocessor SPARCserver 1000, an additional set of tests were run on a 250 Megabyte file. Table 4 provides a summary description of the individual tests performed.

Individual Photoshop Tests

Figure 1 illustrates the results of the Photoshop benchmark for each configuration performing the selected operations on a small 4.84 MByte image while Figure 2 shows the test results as performed on a 72 MByte image. Table 2 and Table 3 list the numerical results of the tests. In each case, the test

was run three times, and only the average is reported. To best illustrate the ratio in performance between systems, each test is normalized to the slowest performing system.

Tested Configurations

To provide a meaningful evaluation, tests were performed on 24-bit systems only, and used any available imaging or display acceleration capability. For example, the SPARCstation™ 5 S24 was tested with the ViTec RasterFLASH™. Table 1 lists the systems tested.

System Tested	Physical Memory	Photoshop Memory	Photoshop Tile Size	Swap Size	Photoshop Version	Special Features
SPARCstation 20 SX	128 MB	64 MB	500	273 MB	2.5.2 Alpha 5	SXcharged[1]
SPARCstation 5 S24	128 MB	48 MB	500	111 MB	2.5.1	S24 & ViTec RF[2]
SPARCserver 1000	544 MB	264 MB	500	400 MB	2.5.2 Alpha 5	MPcharged[3] (8 Proc.)
Silicon Graphics R4400	128 MB	64 MB	500	300 MB	2.5	None
Power Macintosh 8100 (Model 80)	122 MB	80 MB	Default	—	2.5.1	PowerPC Native Plug-in[4]

[1] SXcharged Plug-in. [2] ViTec RasterFLASH - Provides acceleration of selected Photoshop operations.
[3] MPcharged Plug-in. [4] PowerPC Plug-in provides native execution of some Photoshop operations.

Table 1 Adobe Photoshop benchmark system configuration

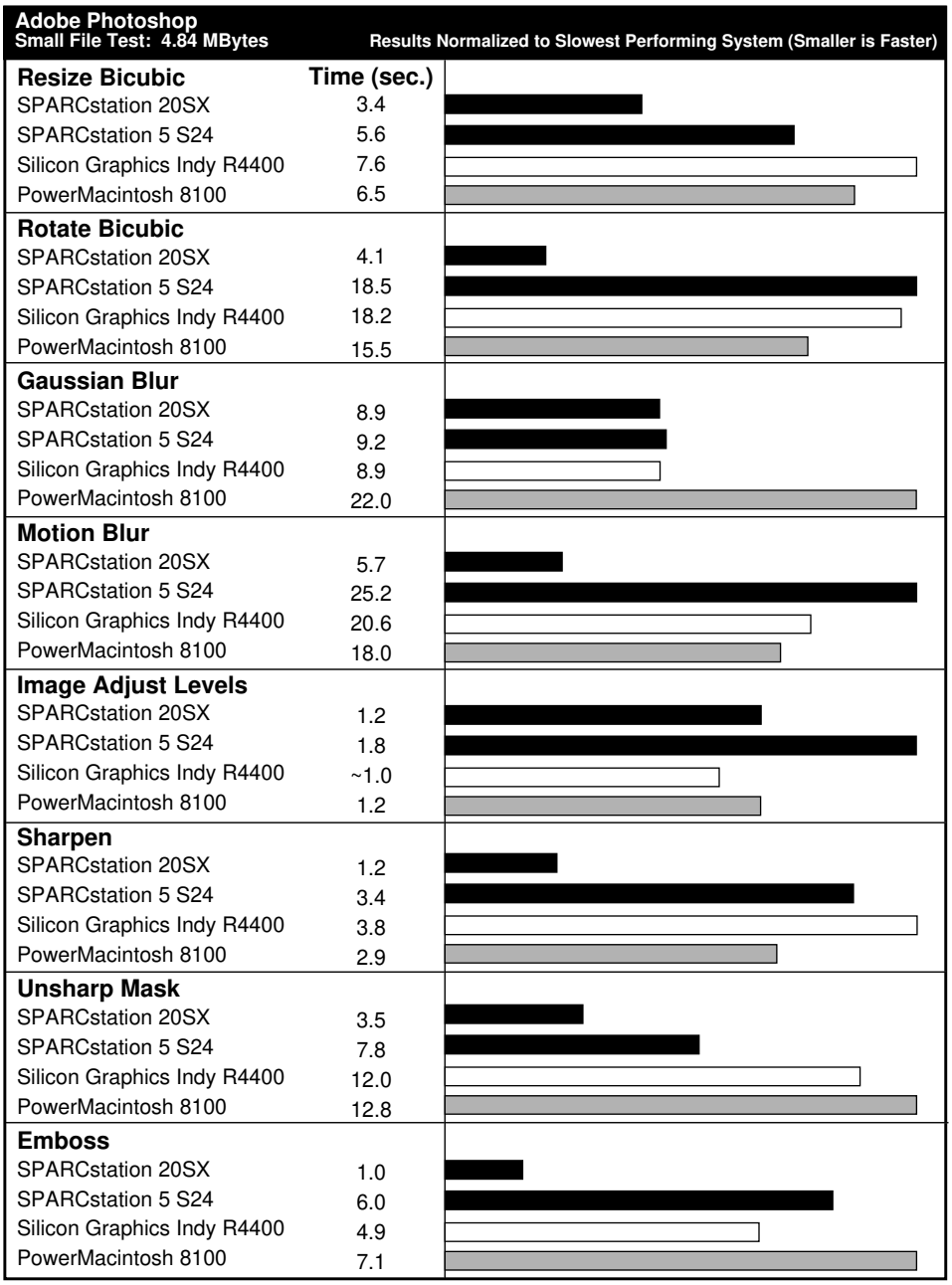

Figure 1 Photoshop benchmarks - Small File (4.84 MBytes)

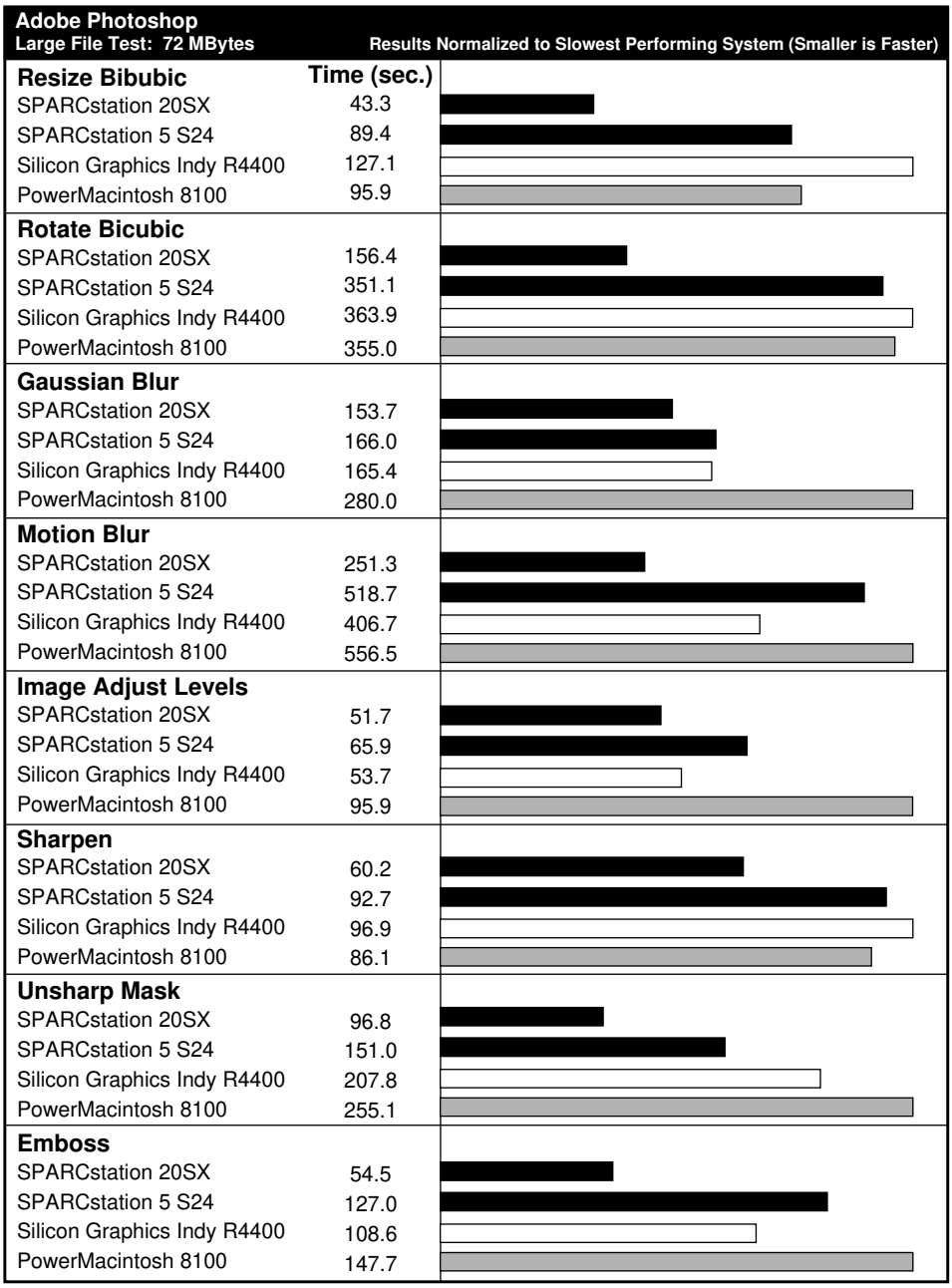

Figure 2 Photoshop benchmarks - Large File (72 MBytes)

Small File Test[1] (4.84 MBytes)	SS20 SX	SS5 S24	SGI R4400	PowerMac 8100
Resize Bicubic	3.4	5.6	7.6	6.5
Resize Bilinear	3.2	4.9	5.3	5.0
Resize Nearest Neighbor	2.3	2.3	0.9	2.5
Rotate Bicubic	4.1	18.5	18.2	15.5
Rotate Bilinear	3.6	17.5	16.0	11.8
Rotate Nearest Neighbor	3.1	17.1	9.3	8.4
Gaussian Blur (10 Pixel)	8.9	9.2	8.9	22.0
Gaussian Blur (2 Pixel)	3.4	6.7	13.0	17.2
Motion Blur	5.7	25.2	20.6	18.0
Image Adjust Levels	1.2	1.8	~1.00	1.2
Sharpen	1.2	3.4	3.8	2.9
Unsharp Mask	3.5	7.8	12.0	12.8
RGB->CMYK Convert	8.0	20.1	10.9	9.0
Emboss	1.0	6.0	4.9	7.1

Large File Test[1] (72 MBytes)	SS 20SX	SS5 S24	SGI R4400	PowerMac 8100
Resize Bicubic	43.3	89.4	127.1	95.9
Resize Bilinear	36.2	70.6	94.7	82.5
Resize Nearest Neighbor	25.4	34.6	21.8	26.6
Rotate Bicubic	156.4	351.1	363.9	355.0
Rotate Bilinear	148.3	325.1	341.4	307.7
Rotate Nearest Neighbor	142.5	377.8	245.6	252.5
Gaussian Blur (10 Pixel)	153.7	166.0	165.4	280.0
Gaussian Blur (2 Pixel)	98.1	133.5	227.4	298.2
Motion Blur	251.3	518.7	406.7	556.5
Image Adjust Levels	51.7	65.9	53.7	95.9
Sharpen	60.2	92.7	96.9	86.1
Unsharp Mask	96.8	151.0	207.8	255.1
RGB->CMYK Convert	162.80	342.3	216.3	113.0
Emboss	54.54	127.0	108.6	147.7

[1] Time in seconds.

Table 2 [3] MPcharged Plug-Small and large file benchmarks data

Data in the bar charts illustrated throughout this performance brief reflect performance normalized (in each individual test) to the slowest performing system.

The image used in the Small File benchmark is taken from the standard Adobe Photoshop sample files, and appears as a single image of a set on contiguous 35mm frames as depicted on a typical proof sheet. The image used in the Large File benchmark was taken from the Kodak™ Photo CD™ Sampler, and is of the young girl with face paint. For the purposes of the benchmark, the image was resized to 72 Megabytes.

Large Image Test

Table 3 and Figure 3 below provide the results of the benchmark suite as tested on the multiprocessor SPARCserver 1000. The system ran Solaris 2.3 and was tested using a multithreaded version of Photoshop which was able to utilize the multiple processors on the system.

The principal relevance of the SPARCserver 1000 is in manipulating very large files, acting as a compute engine for both Photoshop and other imaging applications, and/or performing a broader set of tasks including providing image file services, raster image processing (RIP), and managing I/O devices.

For the purposes of comparison, the benchmarks of the SPARCserver 1000 processing the 250 MByte image are illustrated in Figure 3, together with the same operations performed by the Power Macintosh 8100. As the operation execution time generally scales proportionally with the image size, the reader can extrapolate the approximate time that the operation would complete if other comparative systems had also manipulated the larger 250 MByte image.

The test was performed on the Power Macintosh to provide a frame of reference for measurement relative to the substantial performance delivered by the SPARCserver 1000, a moderately-priced MP-capable system.

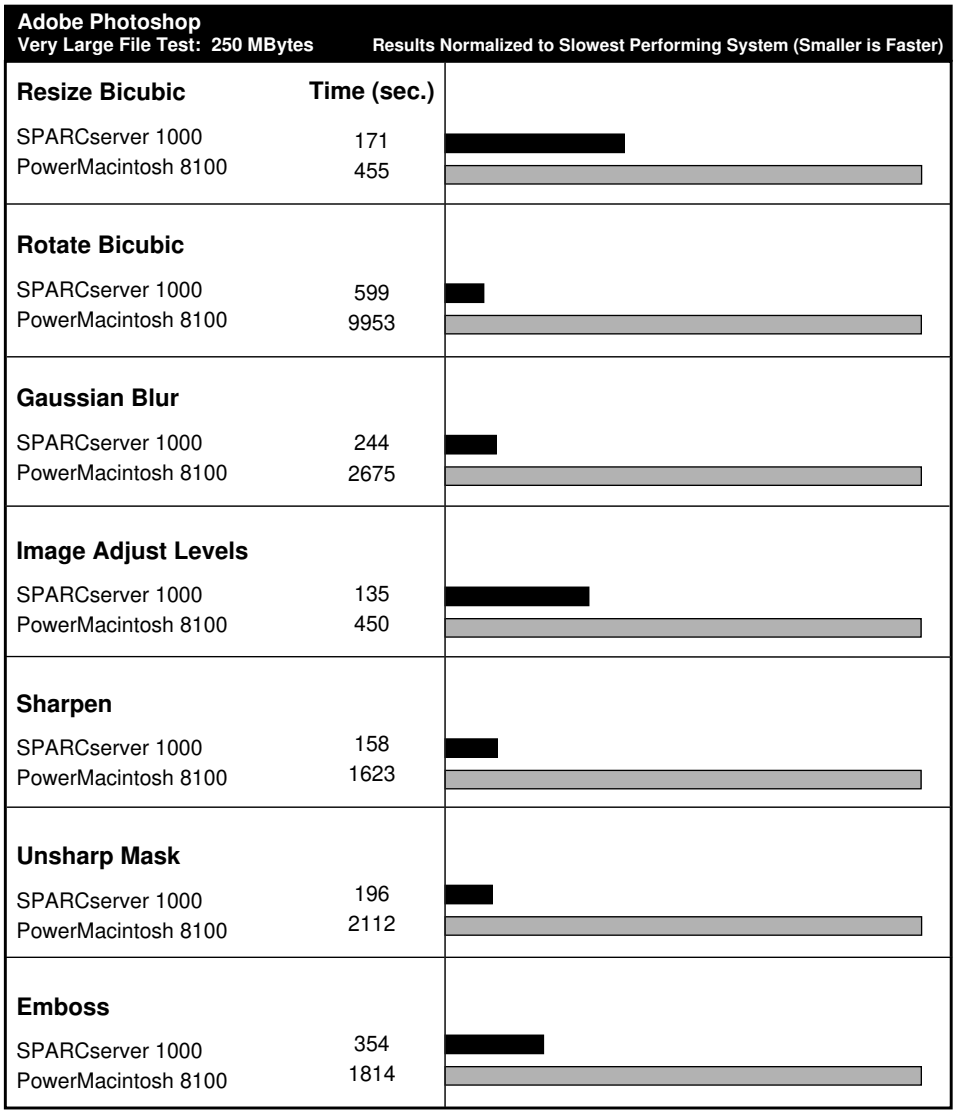

Figure 3 Very large file benchmark (250 MByte)

Very Large File Test[1] (250 MBytes)	SPARCserver 1000 (8 Processor)	Power Macintosh 8100 Model 80
Resize Bicubic	171	455
Resize Bilinear	151	409
Resize Nearest Neighbor	45	331
Rotate Bicubic	599	9953
Rotate Bilinear	545	8883
Rotate Nearest Neighbor	480	8687
Gaussian Blur (10 Pixel)	244	2765
Gaussian Blur (2 Pixel)	244	2451
Image Adjust Levels	135	450
Sharpen	158	1623
Unsharp Mask	196	2112
RGB->CMYK Convert	263	2835
Emboss	354	1814

[1] Time in seconds.

Table 3 Very large file benchmarks - 250 Megabytes

Summary

System performance is important in evaluating the speed at which users can accomplish individual imaging tasks, but quickly loses significance if other bottlenecks in the publishing network are exposed. These bottlenecks, ranging from file I/O and network performance, to CPU processing and graphics display, have long been the bane of Macintosh and PC users.

In distinct contrast to both Macintosh and PC-class machines, Sun's balanced system design delivers both high performance I/O and high-speed networking — important considerations for serious imaging applications and environments.

The Sun SPARCstation 20SX workstation typically delivers 3 to 4 times the average performance of both Apple and Silicon Graphics workstations. For complex operations on large images, this performance margin can easily represent many hours of productivity gain in a given week.

At the same time, the SPARCstation 5 S24, when equipped with the ViTec RasterFLASH board, delivers similar performance to the SGI Indy R4400 at less than half the cost.

Finally, for extremely sensitive performance demanding requirements, or where multiple uses (e.g., image server, RIP server, etc.) are important, the SPARCserver 1000 can perform common Photoshop operations in 1/6 the time of competing systems.

In today's competitive business environment, making timely creative decisions is critical to success. When productivity can be increased through better application and data integration, network connectivity and throughput, users gain greater freedom to exercise their creative energy. Benchmark data aside, Sun's UNIX systems offer the best promise to increase the overall productivity in a network-based publishing environment.

Photoshop Imaging Operations

The benchmark tests performed included a subset of the approximately 50 standard Photoshop operations. These operations, discussed below, represent a cross-section of common Photoshop functions which place diverse demands on a system's resources. Table 4 also provides a list of the tests performed and their initialization parameters.

Test Name	Description
Resize Bicubic	**Resize Image using Bicubic Interpolation** *Small Test:* Resize from 1.12 MBytes to 4.84 MBytes *Large Test:* Resize from 17.9 MBytes to 71.4 MBytes
Resize Bilinear	**Resize Image using Bilinear Interpolation** *Small Test:* Resize from 1.12 MBytes to 4.84 MBytes *Large Test:* Resize from 17.9 MBytes to 71.4 MBytes
Resize Nearest Neighbor	**Resize Image using Nearest Neighbor Interpolation** *Small test:* 72 pixels/inch -> 150 pixels/inch *Large test:* 288 pixels/inch -> 576 pixels/inch
Rotate Bicubic	**Rotate Image using Bicubic Interpolation** 37 degrees Clockwise
Rotate Bilinear	**Rotate Image using Bilinear Interpolation** 37 degrees Clockwise
Rotate Nearest Neighbor	**Rotate Image using Nearest Neighbor Interpolation** 37 degrees Clockwise
Gaussian Blur (10 Pixel)	**Blur Image using Gaussian Function** 10 pixel Diameter
Gaussian Blur (2 Pixel)	**Blur Image using Gaussian Function** 2 pixel Diameter
Motion Blur	**Motion Blur of Image** Selection Parameters: 20 pixel Distance, 30 degree Angle
Image Adjust Level	**Adjust Image Contrast/Brightness Levels** Selection Parameters: 0, .5, 255
Sharpen	**Sharpen Image** Selection Parameters: Default Settings
Unsharp Mask	**Sharpen Image using Unsharp Mask** Selection Parameters: 50%, 1, 0
RGB->CMYK Convert	**Color Mode Conversion** RGB->CMYK Conversion
Emboss	**Emboss Image** Selection Parameters: 135 degrees, 3, 100%

Table 4 Adobe Photoshop benchmark tests

Resize

Resize refers to the conversion of an image of a particular size to a larger or smaller one. During the resize process, the image is effectively scaled, adding or deleting pixels as necessary.

In performing the resize operation, the user has the ability to apply one of several pixel value interpolation algorithms, based upon the level of acceptable image quality. The three resize alternatives are *nearest neighbor*, *bilinear*, and *bicubic*.

Nearest neighbor interpolation is the least demanding computationally, and produces the lowest quality. Using nearest neighbor, the resized image is computed with each new pixel set to the value of its corresponding nearest neighbor pixel in the source image.

Like nearest neighbor, bilinear interpolation is based upon values of the nearby pixels. Bilinear interpolation however, uses the values of the four nearest surrounding source pixels. During the calculation of interpolated values, each new pixel is computed using a bilinear equation with coefficients (weights) based on the surrounding pixels.

Bicubic interpolation is the most demanding of the three methods. Bicubic interpolation uses the 16 nearest neighbor source pixels to set the coefficients of a bicubic equation which is evaluated to find the value of the resulting pixel.

Rotate

Rotate refers to the rotation of an image by a specified angle. During the rotate process, the image must be resampled, because the new image's individual pixels may not fall on integer coordinate locations in original image. This requires that an interpolation mechanism be applied to compute the resulting intermediate pixel values.

As with Photoshop's resize image operation, the user has three alternative interpolation mechanisms for computing the resulting rotated pixel values: *bicubic*, *bilinear*, and *nearest neighbor*. The same characteristic algorithms and their computational demands and quality trade-offs apply to these interpolation schemes when used in image rotation.

Blur

Blur is one of the most commonly used filters in Photoshop. Blur provides a means to smooth the hard edges of a object, such as when retouching or smoothing a pasted selection. Numerous blur filters are available with Photoshop, and among the most computationally demanding are *Gaussian Blur* and *Motion Blur*.

A Gaussian blur operation is a variable smoothing filter which permits the definition of the degree of 'bluriness,' which is dependent upon the number of adjacent pixels used to average each new pixel. The averaging function is based upon a weighting function (Gaussian) having the properties of a bell curve. Source pixels closer to the pixel being calculated have higher weights than those further away. The more pixels used (the broader the function), the more blurring occurs as a result of the operation.

A Motion Blur operation produces a blur effect in a user-specified direction and distance (intensity). The resulting effect is analogous to the blurring caused when photographing a moving object using a fixed exposure time. The Motion Blur operation is based upon replication of the images pixels for a predefined length along an axis at a predefined angle. The pixels are then averaged to produce a blurring effect typical of motion.

Adjust

Image *Adjust Levels* provides an accurate means to precisely adjust the brightness and contrast levels of an image. The operation is performed through three user-selectable input parameters for setting the contrast of the brightest, darkest, and midtone values of the image.

Adjusting the image's levels consists of the process of scaling the overall image pixel brightness value histogram to match the input parameters mentioned above.

Sharpen

The *Sharpen filter* is a common Photoshop operation used to produce 'sharpened' images from blurry ones. The sharpen filter achieves this result by increasing the contrast between adjacent pixels by a default amount. The *Sharpen More* filter uses an even larger default to increase the sharpen effect.

Another of the image sharpen filters provided with Photoshop is *Unsharp Mask*. This filter provides the most effective way to perform user-definable sharpening. The unsharpen mask process is the digital equivalent of the analog technique used by photographers. Essentially, the unsharp mask filter produces a copy of the image, converts it to a negative (inverting the color value of all pixels), blurs the result, and then averages it with the original image. Finally, the image is brightness balanced.

The resulting image produced by the Unsharp Mask appears sharper because the image is only processed where significant brightness differentiation exists. Unsharp Mask allows the selection of the amount of weight used in the blend (average) portion of the operation, the radius of the blur operation, and the threshold value for brightness differentiation.

Mode Conversion

Mode Conversion selections under Photoshop enable the user to convert images to different color spaces and numbers of channels. This capability is particularly important because images may come from different sources, significant differences usually exist between color CRT display and printer output, and users often need to manipulate images in one space and then convert them to another.

Many users of Photoshop work in RGB (red-green-blue) color space during image editing, and convert to CMYK (cyan-magenta-yellow-black) color space when producing separations as required by traditional four-color printing processes.

When converting from an RGB format to CMYK, Photoshop first separates the RGB values into CIE[1] L*a*b* values, and then constructs a three-dimensional color table. The original image is converted by interpolation of the L*a*b* values in the color table and converting the image's pixels to their CMYK equivalents.

1. Commission Internationale d'Eclairage

Emboss

Emboss is a stylized filter operation which performs a custom convolution matrix on the image (or selected subregion). Emboss has the effect of making the selection appear 'raised' or 'stamped', and can be used to produce an embossed appearance. The emboss operation produces this effect by suppressing the color values within a selection, and tracing detected edges in black.

Emboss can be described as enhancing the difference between a shifted copy of an image and the image itself. Areas with even brightness and color become flat gray, edges are lightened one one side and darkened on the other. Emboss is mainly a test of memory access speed, since it does little computation.

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